10. Surficial Cap

10.1 General

Another major component of the RC for the site was the construction of a surficial cap to form a low-permeability horizontal barrier across the site to reduce infiltration, divert surface water, and vent gases that may generate beneath the surficial cap. The west, south, and east sides of the surficial cap were terminated at the slurry trench cutoff wall, and the north side of the surficial cap was tied into the floodwall. The surficial cap was constructed in accordance with the *Final Modified (100%) Remedial Design Report* (ECKENFELDER, 1999), with the exception of some minor modifications (Section 17). Construction of the surficial cap commenced once the finished subgrade was established, as discussed in Section 9.3. At that time, the majority of the surficial cap was constructed, with the exception of the area containing the interim treatment plant (Section 13.3). Once the interim treatment plant was demobilized from the site, the remaining portion of the surficial cap was constructed between late November and early December 2001.

The primary components associated with the surficial cap construction, in the order that they were installed, include the following:

- gas venting layer;
- GCL;
- 60-mil textured high-density polyethylene (HDPE) geomembrane;
- geocomposite drainage layer;
- select fill layer (or top protective layer); and
- top gravel layer (or composite surface layer).

Several field modifications to the surficial cap were approved by Brown and Caldwell and implemented, as discussed in Section 17. A description of each primary component associated with the surficial cap construction, the miscellaneous components that were installed above the surficial cap, and the associated QC/QA testing performed is presented below.

10.2 Preconstruction Testing

Before constructing the surficial cap, three laboratory tests were performed on the cap cross section using the approved geosynthetic and cover soil materials to determine the lowest interface friction angle between the following:

- gas venting layer and GCL;
- GCL and 60-mil textured HDPE geomembrane; and
- 60-mil textured HDPE geomembrane and geocomposite drainage layer.

These three tests were performed by J & L Testing Company, Inc., as a subcontractor to Sevenson, at its Stone Mountain, Georgia facility using an interface shear device. Each test was performed using three different normal stresses (i.e., 100, 250, and 500 pounds per square foot) and a contact area of 12 inches by 12 inches. Prior to performing each test, the materials were wetted to simulate saturated field conditions. Each test was performed at a shear rate of 0.04 inches per minute, for a total displacement of at least 2.5 inches to accurately define residual stress.

Based on the results of the three tests performed, the interface friction angle for each test exceeded the minimum friction angle of 21 degrees; therefore, the use of the proposed geosynthetic materials was approved and acceptable for use for the surficial cap. The results of the friction angle for each interface tested are included in Appendix R.

10.3 Gas Venting Layer

The lowest layer of the surficial cap was the gas venting layer. This layer was installed directly above the final subgrade (Section 9.3) and provides a reasonably uniform, stable base for the placement of geosynthetic materials, as well as a means to convey gas beneath the geosynthetic materials to avoid a potential pressure buildup. The gas venting layer consists of a layer of nonwoven geotextile fabric and a 12-inch-thick layer of gravel/crushed stone that was graded in place using a track dozer. The geotextile fabric was placed first over the prepared subgrade, using a minimum seam overlap of 6 inches, followed by the placement of the 12-inch-thick layer of gravel/crushed stone. The thickness of the gas venting layer was verified by survey stakes and was also verified based on the contour drawings included on Record Drawings Nos. 6 and 7.

Once the gas venting layer was installed, a total of 14 gas vents were installed throughout the site, in accordance with Drawing 9527-004 in the drawings from the *Final Modified (100%) Remedial Design Report* (ECKENFELDER, 1999). The gas vents were constructed with perforated/solid Schedule 40 PVC pipe, in accordance with the details shown on Drawing 9527-030 in the drawings from the *Final Modified (100%) Remedial Design Report* (ECKENFELDER, 1999). The bottom piping for each gas vent was installed entirely in the gas venting layer, and the vertical section of piping extended from the gas venting layer to approximately 1.5 feet above the final surficial cap surface (Record Drawing No. 9).

Since the gas venting layer consisted of a coarse aggregate with minimal fines, there were no compaction requirements. Section 2.4 identifies the geotechnical testing that was performed on the gravel/crushed stone both prior to and during placement. Based on the *Final Modified (100%) Remedial Design Report* (ECKENFELDER, 1999), there were no onsite QC testing requirements for the gravel/crushed stone material. The QC/QA testing requirements that were performed on the geotextile fabric are discussed in the following sections.

10.3.1 Manufacturer's QC Testing and Certification for Nonwoven Geotextile Fabric

To demonstrate that the selected nonwoven geotextile fabric conformed to the requirements identified in the *Final Modified (100%) Remedial Design Report* (ECKENFELDER, 1999), the geotextile manufacturer (TC Mirafi) performed QC testing on the geotextile fabric at a minimum frequency of once every 40,000 square feet, and certified that the material was in compliance with the required property values. The QC testing parameters included apparent opening size, permittivity, puncture strength, tensile strength, grab elongation, trapezoidal tear, and Mullen burst. The geotextile fabric was not tested for porosity, since there is no ASTM-established method available for this parameter; however, TC Mirafi provided a certification that determined that the porosity for this material is greater than or equal to the specified value (30%) in the *Final Modified (100%) Remedial Design Report*, which was approved by Brown and Caldwell (Appendix A13).

Based on the QC testing performed on the nonwoven geotextile fabric by the manufacturer, the testing results were in compliance with the values specified in the *Final Modified (100%) Remedial Design Report* and were acceptable for use for the surficial cap. The QC testing results for the nonwoven geotextile fabric are included in Appendix S.

10.3.2 QA Testing for Non-Woven Geotextile Fabric

BBL performed additional QA testing of the nonwoven geotextile fabric. Samples of nonwoven geotextile fabric were collected from five different rolls and submitted to J & L Testing for the same test parameters identified in Section 10.3.1. Based on the QA testing performed on the nonwoven geotextile fabric, the testing results for these samples were also in compliance with the values specified in the *Final Modified (100%) Remedial Design Report* (ECKENFELDER, 1999) and were acceptable for use for the surficial cap. The QA testing results for the nonwoven geotextile fabric are included in Appendix T.

10.4 Geosynthetic Clay Liner

Once the gas venting layer was final graded, a GCL was installed over the gravel/crushed stone. Prior to placing the GCL, BBL and Sevenson inspected the gravel/crushed stone surface to verify that the surface was acceptable for the placement of geosynthetic materials. As a result of this inspection, Sevenson provided a written certification indicating that the surface on which the GCL would be installed was acceptable for GCL deployment (Appendix U).

Once the gravel/crushed stone surface was certified acceptable, the GCL material was deployed. The seams of each GCL panel were generally installed parallel to the slope and were overlapped a minimum of 6 inches. Once in place, the GCL panels were pulled tight to maximize contact with the gas venting layer and to smooth out any wrinkles or creases between adjacent panels. Any holes or tears in the GCL were repaired, as discussed in Section 10.4.3. The deployment of GCL during a given day was monitored closely to confirm that all GCL placed during a day's work was covered with geomembrane and protected from entrance of any water at the end of the work day.

BBL observed the deployment of the GCL to verify that the surface was dry, the GCL was not hydrated, the seams were perpendicular to the slope and overlapped a minimum of 6 inches, all GCL was covered with geomembrane (with all seams welded) at the end of each work day, the GCL panels were pulled tight to minimize wrinkles, and all tears/holes in the GCL were repaired appropriately (Section 10.4.3). In addition, several other manufacturing QC and QA tests were performed on the GCL, as discussed in the next two sections.

10.4.1 Manufacturer's QC Testing and Certification for Geosynthetic Clay Liner

To demonstrate that the selected GCL conformed to the requirements identified in the *Final Modified (100%) Remedial Design Report* (ECKENFELDER, 1999), the GCL manufacturer, Colloid Environmental Technologies Company, performed QC testing on the GCL at a minimum frequency of once every 40,000 square feet and certified that the material was in compliance with the required property values for clay mass per area, grab strength, puncture resistance, permeability, internal friction angle, peel strength, bentonite swell index, bentonite free swell, and index flux. The QC testing parameters included thickness and hydraulic conductivity.

Based on the QC testing performed on the GCL by the manufacturer, the testing results were in compliance with the values specified in the *Final Modified (100%) Remedial Design Report* (ECKENFELDER, 1999) and were acceptable for use for the surficial cap. The QC testing results for the GCL are included in Appendix V.

10.4.2 QA Testing for Geosynthetic Clay Liner

BBL initiated QA testing of the GCL. Samples of GCL were collected from three different rolls and submitted to J & L Testing for the same test parameters identified in Section 10.4.1. Based on the QA testing performed on the GCL, the testing results for these samples were also in compliance with the values specified in the *Final Modified (100%) Remedial Design Report* (ECKENFELDER, 1999) and were acceptable to use for the surficial cap. The QA testing results for the GCL are included in Appendix W.

10.4.3 Repairs to Geosynthetic Clay Liner

Any holes, tears, or punctures that were made in the GCL during placement were repaired by placing a GCL patch over the damaged section, with the patch overlapping the edges of the hole, tear, or puncture by at least 1 foot in all directions. BBL and Sevenson inspected the GCL to verify that all repairs were made prior to deployment of the 60-mil HDPE textured geomembrane.

10.5 Textured HDPE Geomembrane

Upon the completion of GCL installation, a layer of 60-mil textured HDPE geomembrane was installed over the GCL in accordance with an initial geomembrane panel layout. Before placing the geomembrane, the GCL surface was inspected by BBL and Sevenson's subcontractor for geomembrane installation, New England Liner, to verify that the surface was acceptable for deployment of geomembrane. As a result of this inspection, New England Liner provided a written certification indicating that the surface on which the geomembrane would be installed was acceptable for geomembrane deployment (Appendix U).

Once the GCL was certified acceptable, the 60-mil textured HDPE geomembrane was deployed. The seams of each geomembrane panel were generally oriented parallel to the line of maximum slope (i.e., oriented down the slope, not across the slope). The geomembrane panels were not placed at times when ambient temperatures were below 32°F or during any precipitation events. Once in place, the geomembrane panels were pulled tight to maximize contact with the GCL and to minimize wrinkles. At the end of each work day, all exposed sections of GCL were covered with a layer of geomembrane and protected from the migration of any surface water.

Once a geomembrane panel was placed, an identification number was assigned to that panel; this was recorded and observed by BBL. The geomembrane seams were installed parallel to the slope, with a minimum overlap of 3 inches for seams requiring extrusion welding and 5 inches for seams requiring fusion welding. Prior to welding of the geomembrane seams, the seam area was cleaned and freed of moisture, dirt, debris, and any other foreign material that might affect the seam weld, and was inspected/approved by BBL. Once cleaned and inspected/approved, the seams were welded with either an extrusion welding apparatus or a fusion welding apparatus (providing double fusion seams). Upon the completion of welding the seams, various onsite QC tests

(Section 10.5.3) were performed to demonstrate the integrity of the field seams. Also, the geomembrane panels were inspected for any holes, tears, or punctures and were repaired appropriately (Section 10.5.4) and retested.

Upon the completion of the geomembrane installation, a final geomembrane panel layout was prepared (Record Drawing No. 8), and the final top of geomembrane elevations was surveyed (Record Drawing No. 7).

A summary of the various QC and QA testing that was performed on the geomembrane, both before and during installation, is presented below in Sections 10.5.1, 10.5.2, and 10.5.3.

10.5.1 Manufacturer's QC Testing and Certification for Geomembrane

To demonstrate that the selected 60-mil textured HDPE geomembrane conformed to the requirements identified in the *Final Modified (100%) Remedial Design Report* (ECKENFELDER, 1999), the geomembrane manufacturer, GSE Lining Technology, Inc., performed QC conformance testing on the geomembrane at a minimum frequency of once every 40,000 square feet and certified that the material was in compliance with the required property values. The QC conformance testing consisted of thickness, density, tensile properties at each direction (i.e., strength at break, strength at yield, elongation at break, and elongation at yield), carbon black content, and carbon black dispersion. In addition, the manufacturer certified that soil burial resistance, environmental stress crack, and low temperature brittleness tests had been performed on the geomembrane sheets made from the same type of resin used for this site.

Based on the QC testing performed on the geomembrane by the manufacturer, the testing results were in compliance with the values specified in the *Final Modified (100%) Remedial Design Report* (ECKENFELDER, 1999) and were acceptable for use for the surficial cap. The QC testing results for the geomembrane are included in Appendix X.

10.5.2 QA Testing for Geomembrane

BBL initiated QA testing of the geomembrane. Samples of geomembrane were collected from three different rolls and submitted to J & L Testing for the same QC conformance testing parameters identified in Section 10.5.1. Based on the QA testing performed on the geomembrane, the testing results for these samples were also in compliance with the values specified in the *Final Modified (100%) Remedial Design Report* (ECKENFELDER, 1999) and were acceptable for use for the surficial cap. The QA testing results for the geomembrane are included in Appendix Y.

10.5.3 Onsite QC Testing for Geomembrane

During deployment of the 60-mil textured HDPE geomembrane, several onsite QC tests were performed for the welded seams to demonstrate the integrity of the field seams. In general, these QC tests included trial seam weld testing, nondestructive seam testing, and destructive seam testing. A summary of the QC tests performed and the associated results are presented below.

10.5.3.1 Trial Seam Weld Testing

A trial seam weld was made at the beginning of each day, and at least once every 4 hours for that day, for each production seaming apparatus (i.e., extrusion welding apparatus and fusion welding apparatus) scheduled to be used that day. The purpose of the trial seam was to verify that seaming conditions and the seaming apparatuses are adequate for production seaming. The trial seams were welded under the same conditions as the actual field seams and were approximately 10 feet long by 1 foot wide for fusion trial seams and 3 feet long by 1 foot wide for extrusion trial seams.

A total of four 1-inch specimens were cut from each trial seam at randomly selected locations, except for the first and last few inches along the trial seam. Two seam samples were tested for peel adhesion, and the other two samples were tested for shear strength. The trial seam weld tests were performed onsite using a field tensiometer and required a minimum shear strength of 113 pounds per inch, and a minimum peel adhesion of 88 pounds per inch for fusion trial seams and 63 pounds per inch for extrusion trial seams. If a specimen failed, a new trial seam was made using the same welding apparatus and was retested; this procedure continued until the deficiencies were corrected and two consecutive successful trial seams were achieved.

The trial seams and testing were performed by New England Liner and observed by BBL. The trial seam weld tests were recorded on logs and are included in Appendix Z.

10.5.3.2 Nondestructive Seam Testing

The integrity of all field seams for the geomembrane was tested nondestructively over their full length using either a vacuum box test for extrusion welded seams or an air pressure test for fusion welded seams. The nondestructive seam testing was performed as the seaming work progressed during each day. The method used to perform each of these tests included the following:

- A strip of the extrusion weld seam was first wetted with a soapy solution, and the vacuum box was placed over the wetted seam. The exterior seal of the vacuum box was sealed tightly to the geomembrane, and a vacuum pressure of approximately 5 psi gauge was applied for a minimum of 30 seconds. If no bubbles appeared after the test period, the vacuum box was moved to the next adjoining area, with a minimum overlap of 3 inches, and the process was repeated for the entire length of the seam. Areas where soap bubbles appeared during the test period were marked and repaired/retested appropriately (Section 10.5.4). The final results of the vacuum box testing passed and are included in Appendix AA.

  The test period was later changed during the geomembrane installation to approximately 10 seconds, since the vacuum box is capable of identifying a leak in the liner immediately. The change in the test duration was approved by Brown and Caldwell (Appendix A14).

- Both ends of a fusion weld seam were sealed leak-tight, and a needle (connected to a sealed pressure feed device) was inserted into the air channel created by the fusion weld. An air pump then initiated an air pressure between 25 and 30 psi in the air channel and the pressure gauge was observed for a minimum test period of 5 minutes. If a pressure loss exceeded 3 psi over the test period, the location of the faulty area was repaired appropriately (Section 10.5.4) and retested. If pressure loss did not exceed 3 psi over the test period, the seam passed, and the opposite end of the seam was cut to verify continuity of the air pressure. If the air did not escape, the blockage was located and repaired/retested appropriately (Section 10.5.4). The areas that were disturbed during the air pressure testing were repaired/retested appropriately (Section 10.5.4). The final results for the air pressure testing passed and are included in Appendix AA.

10.5.3.3 Destructive Seam Testing

Destructive seam tests were performed on samples collected from selected locations on the deployed/welded geomembrane to evaluate seam strength and integrity. These tests were performed as the seaming work progressed in order to obtain laboratory test results before the geomembrane was covered by another material. A minimum of one destructive test sample was collected for every 500 linear feet of seam length. The method used to perform the destructive seam test includes the following:

- Two strips of a welded seam, approximately 12 inches long by 1 inch wide, were collected from either side of the sample location and tested for peel adhesion and shear strength using the onsite tensiometer. If the test results were below the minimum peel adhesion and shear strength values (Section 10.5.3.1), the entire seam was repaired appropriately and retested (Section 10.5.4).

- If the test results passed, a sample 3.5 feet long by 1 foot wide was collected from the sample location and cut into three sections. One 1-foot-long section was given to New England Liner for its records, one 1.5-foot-long section was submitted to BBL for QA testing, and a final 1-foot-long section was submitted to Tierra for archival storage. At a minimum, the archived geomembrane samples will remain in storage until the FRRC is approved by the USEPA.

- BBL submitted the 1.5-foot-long sample to J & L Testing for QA testing for shear strength and peel adhesion to determine whether it complied with the minimum values (Section 10.5.3.1). A minimum of five specimens were tested by J & L Testing, and the results were submitted to BBL immediately upon test completion.

- If the destruction seam sample test result failed, the seam was repaired appropriately and retested (Section 10.5.4).

The final results for the destructive seam testing passed and are included in Appendix BB.

10.5.4 Repairs and Retesting

Any portion of the geomembrane that exhibited a flaw or failed an onsite QC test (Sections 10.5.3.2 and 10.5.3.3) for a seam was repaired and retested. Patches, consisting of a piece of geomembrane with all corners rounded and a radius of approximately 3 inches, which extended at least 6 inches beyond the edge of the defect, were used for most repairs. Each repair was then numbered and logged and was retested, primarily with a vacuum box. Failed tests were again repaired and retested until a passing test result was achieved. A summary of the geomembrane repair/retest logs are included in Appendix CC.

10.6 Geocomposite Drainage Layer and Geocomposite Drain Pipes

Upon the completion of the installation of sections of the 60-mil textured HDPE geomembrane, a geocomposite drainage layer (GDL) and geocomposite drain pipes were installed over the geomembrane. The geocomposite drain pipes were installed over the GDL to facilitate subsurface drainage patterns above the geomembrane. A summary of the GDL and geocomposite drain pipe installation is presented below.

10.6.1 Geocomposite Drainage Layer

The GDL consisted of a composite of triplanar HDPE geonet sandwiched between two layers of geotextile fabric. The GDL panels were installed over the geomembrane, with the seams of each panel generally oriented parallel with the line of maximum slope. Once in place, the GDL panels were pulled tight to maximize contact with the geomembrane and to minimize wrinkles. The seams of the geonet component of the GDL were overlapped by at least 3 inches and were secured with nylon cable ties at a minimum of 5 feet along the slope, every 2 feet across the slope, and every 10 feet on horizontal surfaces. The seams of the geotextile fabric of the GDL were overlapped for the bottom layer, and the geotextile was overlapped a minimum of 3 inches and continuously sewn with polymeric thread for the top layer.

If the top geotextile fabric layer was damaged, a new piece of fabric, extending approximately 2 feet beyond the edges of the hole or tear, was heat sealed to the top geotextile fabric in place. If the GDL was damaged, the damaged area was cut out and replaced with a new piece of GDL. The geonet component was secured with nylon cable ties (using the same minimum frequency identified above), and the top geotextile fabric was extended approximately 12 inches beyond the edge of the new piece of geonet patch and heat sealed to the top geotextile fabric in place.

In addition, several other manufacturing QC tests and QA tests were performed on the GDL, as discussed in the next two sections.

10.6.1.1 Manufacturer's QC Testing and Certification for the Geocomposite Drainage Layer

To demonstrate that the selected GDL conformed to the requirements identified in the *Final Modified (100%) Remedial Design Report* (ECKENFELDER, 1999), the GDL manufacturer, Tenax Corporation, performed QC testing on the GCL at a minimum frequency of once every 40,000 square feet, and certified that the material was in compliance with the required property values. The QC conformance testing consisted of the following:

- Geonet Component – Specific gravity, carbon black content, and thickness;
- Geotextile Component – Mass per unit area, apparent opening size, permittivity, puncture strength, grab strength, and trapezoidal tear strength; and
- Geotextile/Geonet/Geotexile Composite – Peel strength.

In addition, the manufacturer certified that hydraulic transmissivity tests had been performed on samples of GDL identical to the product used for this site.

Based on the QC testing performed on the GDL by the manufacturer, the testing results were in compliance with the values specified in the *Final Modified (100%) Remedial Design Report* (ECKENFELDER, 1999) and were acceptable for use for the surficial cap. The manufacturer's QC testing results for the GDL are included in Appendix DD.